LB 20.5
EE
cop 2

MIAMI UNIVERSITY
OXFORD O.
LIBRARY

ENGINEERING-EDUCATION

Bulletin of the
Society for the Promotion of Engineering Education

Vol. VIII LANCASTER, PA., FEBRUARY, 1918 No. 6

Books by C. Frank Allen

Business Law for Engineers

456 pages, 6x9, buckram binding. $3.00.

This book presents the basic legal principles which enter into engineering relations. The first part takes up the fundamentals of law which every engineer should know. The second part shows the application of these principles to the daily work of the engineer in respect to advertisements, bidding, proposals, contracts, bonds and specifications. Typical forms are included.

Railroad Curves and Earthwork Field and Office Tables

In one volume—516 pages, flexible binding, pocket size, gilt edges. $3.00.

In two parts—Railroad Curves and Earthwork, 234 pages. $2.00.
Field and Office Tables, 282 pages. $2.00.

Used in 80 per cent. of the leading engineering schools. As a textbook for the classroom and as a handbook for the engineer in practice, this work has received unqualified approval.

McGRAW-HILL BOOK COMPANY, Inc.
239 West 39th Street New York

Entered as second class-matter, August 24, 1912, at the Post Office at Lancaster, Pennsylvania, under the Act of August 24, 1912

The Link Between The Class and Its Future

Engineering students who read technical magazines during their junior and senior years enjoy an advantage over those whose education is confined strictly to classroom work. The technical magazine links school work to the future work of the student. It gives him a clear view of present day practice, trues his perspective, fits him for a flying start after graduation.

Choose the magazine that will help your classes from this list of

McGraw-Hill Engineering Periodicals

Electrical World

For electrical and mechanical engineering students. It covers every activity of the electrical engineer. Published weekly. $3 a year. Student Rate $2.50 in U. S. and Canada.

Electric Railway Journal

For students who intend to specialize in the transportation field. Design, construction, operation, management. Weekly. $3 a year. Student rate $2.50 in U. S. and Canada.

Metallurgical and Chemical Engineering

For chemical engineers and metallurgists. A great technical newspaper. Semi-monthly. $3 a year. $2.50 to students in U. S. and Canada.

Engineering News-Record

The acknowledged authority in the field of civil engineering and construction work. Published weekly. $5 a year. Student Rate $3.50 in U. S. and Canada.

American Machinist

Gives the student an insight into workaday machine design and construction; machine shop management; machine tool operation and methods of marketing machinery. Weekly. $4 a year. Student Rate $3.00 in U. S. and Canada.

Engineering and Mining Journal

Deals broadly and efficiently with the metal mining and metallurgy of minerals other than coal and iron. Weekly. $5 a year. Student Rate $3.00 in U. S. and Canada.

Power

For students desiring a knowledge of power plant engineering and the generation and transmission of power in all industries. Weekly. $2 a year. Student Rate $1.50 in U. S. and Canada.

Coal Age

It deals with every phase of modern coal mining and coke manufacture, including the production of by-products; fuel markets; contracts and prices. Weekly. $3 a year. Student Rate $2.00 in U. S. and Canada.

Electrical Merchandising

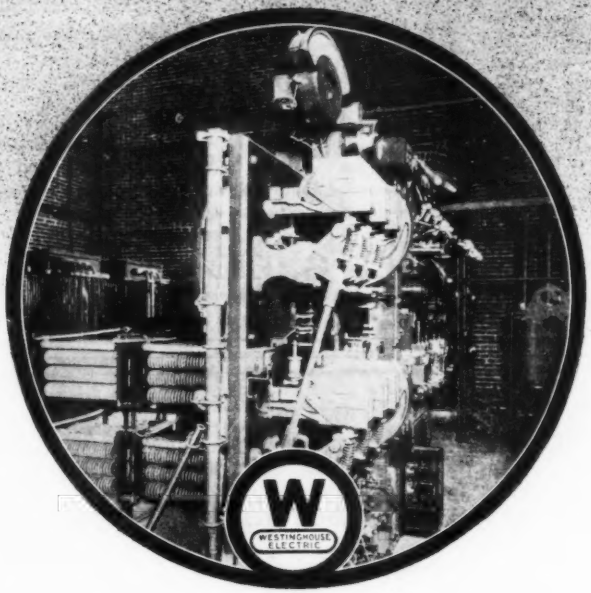
Equips the student with excellent working knowledge of the selling of electrical appliances and electric service. Monthly. $2 a year.

McGraw-Hill Publishing Co., Inc.

NEW YORK

Westinghouse

Automatic Control For Substations



Automatic Control for Substations has been made practicable by producing an assembly of existing equipment to switch substation machinery with simplicity.

It is an adaptation of well known Westinghouse automatic motor-control apparatus which switches substation equipment exactly as in manual operation.

The secret of its success is using proven apparatus on a fundamentally sound basis.

Westinghouse Electric & Manufacturing Co.

EAST PITTSBURGH, PA.

When Your Students

Secure jobs that include "**testing**," they are very likely to be **required** to measure insulation resistance with a

Megger Testing Set

Therefore why not make them **familiar with the** "**Megger Method**," before leaving school or college?

Sooner or later, we believe a Megger will be found in each well equipped Engineering Laboratory; and shall be glad to do our part, by supplying full particulars (**including catalog**) upon request.

JAMES G. BIDDLE

1211-13 Arch Street PHILADELPHIA

The Leeds & Northrup Co.

Electrical Measuring Instruments of Precision

for use in Engineering Laboratories

Our publications contain much scientific information of interest to Engineers. If you are not receiving this literature may we place your name upon our mailing list?

4910 Stenton Ave. **PHILADELPHIA**

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

Milo S. Ketchum, G. R. Chatburn, F. L. Bishop, *Editor.*

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. VIII LANCASTER, PA., FEBRUARY, 1918 NO. 6

TABLE OF CONTENTS.

Perspective in Engineering Education. By Clement C. Williams .. 226
The Effect of the War on Engineering Education. By C. R. Mann. 230
Outline of Course in Direct-Current Machinery. By H. C. Bartholomew 236
Utilizing Engineering Students—A Need and a Plan 249
Editorial 252
Letters to the Editor 252
Book Reviews 253
College Notes 255

PERSPECTIVE IN ENGINEERING EDUCATION.

BY CLEMENT C. WILLIAMS,

Professor of Railway Engineering, University of Kansas, Chairman of Committee on Economics, Society for Promotion of Engineering Education.

Is it not a fact that technical education has not been as effective as it might have been, due to the limited perspective in teaching and in studying? The writer is inclined to believe that his own teaching has suffered from this cause and from observation concludes that such is the case more or less generally. The student is not taught to look beyond the immediate conditions of the problem confronting him to the background of associated circumstances and ultimate relationships. This fragmentary and partial mode of thought thus formed by the student in the classroom problems and discussions influences his procedure and practices in his professional life later. Two instances within the writer's recent observation illustrate the idea in mind.

One draftsman in designing a turntable to carry Mikado locomotives used Cooper's E–60 wheel loadings. Cooper's wheel loadings apparently represented to him a stock set of conditions for the calculation of stresses, to be used always when stresses were to be computed for locomotive loads, and he proceeded accordingly without taking into consideration the fact that the greater wheel spacing of a Mikado type of locomotive would cause greater moment on a cantilever turntable than would the concentrated or closely spaced loadings of Cooper's series, which, of course, were arranged to give maximum moment in simple spans. He had not looked beyond the immediate problem of calculating stresses and proportioning parts. In the other case, a draftsman designed a reinforced concrete icehouse that was the acme of perfection

as a reinforced concrete structure, but owing to the neglect of any consideration of the thermal conductivity of the walls, it would have served its purpose as a preserver of ice but poorly.

The faults in both of these cases were similar in character, namely, the viewpoint was only immediate, while the ultimate and complete relationships had been ignored. It is the writer's opinion that the effect of such faulty processes may be traced in the larger features of engineering practice, particularly with reference to the economic phases of engineering.

The old definition of Tredgold's given in 1828 and frequently quoted, that "Engineering is the art of diverting the forces of nature for the use and convenience of man," has doubtless done the profession much harm, or, at least, the conception thus expressed has done it harm, because of its incompleteness and inadequacy. It served, perhaps, for the beginnings of engineering but it should scarcely be used to define the limits or to set the boundaries of engineering at the present time. The definition would more nearly fit the modern profession if it read: "Engineering is the *science, art* and *business* of diverting *economically* the forces and materials of nature for the use and convenience of man," for engineering is all of these.

Engineering is a science because it requires an intimate knowledge of scientific laws and principles for its successful practice. It takes the high potential concepts of pure science and steps them down through its transformers of plans and specifications so that the lay constructor, contractor or carpenter can understand and apply the same. It is an art, for it has to do with achievement. There is a vast deal of difference between knowing *how to do a thing* and knowing *how to get the thing done.* Engineering recognizes this fact and couples to the knowledge of science the art of achievement. Engineering is also a business, for it has a commercial aspect; it aids its practitioner in making a living and it is directly concerned with producing, exchanging and distributing the

world's wealth. Moreover, unless a given engineering work is connected up and correlated in the scope of the plans to these phases of economic organization, there is still something lacking in its design. This last sentence perhaps should be amplified somewhat.

Engineering economics has been too narrowly conceived. To select a structure or machine so that the total annual charge or cost consisting of fixed charges, maintenance, depreciation, and operating expenses shall be a minimum is certainly not the sum total of engineering economics. This simple mathematical relationship is neither complete nor adequate. Minimum annual cost is not more important, perhaps it is less important, than maximum annual net earnings. Engineering has been held in rather low esteem, a sort of necessary evil, by capitalists and managers, because it has concerned itself so completely and has been so inextricably associated with the *spending* of money rather than with the *earning* of money. More emphasis should be placed on the value and benefits derived from engineering operations and less on the details of spending the money, although the careful study of this latter phase should be by no means neglected. Engineering economics, therefore, should take into consideration the ultimate purpose of the structure, machine or project. Irrigation projects have failed in many instances, notwithstanding the fact that dam, canal, headworks and all other parts were selected on sound scientific and "economic" principles, because the ultimate phase of the problem, namely the settling of the population on the land, the tillage of the soil and the marketing of the crops, was not considered. Many hydro-electric plants have been failures to a greater or lesser extent not because the plant and machinery were not well designed but on account of a lack of market for the power developed. Railroads have gone into the receiver's hands in many instances not because the grades and alignment were poorly selected, but because there was no traffic or else the location was not properly designed to serve well the traffic

that was secured. In these cases, and others might be mentioned, the ultimate relationships were not duly considered. Another definition of an engineer that contains a grain of truth, and a pound of untruth because of its incompleteness, should be mentioned in this connection. It is: "An engineer is a man who can do with one dollar what a fool could do with two." The fact is that an engineer may be the man who can do well and adequately with two dollars what a fool will try to do with one. If the additional expenditure would make the project in character and scope commensurate with the technical and economic needs of the situation while the smaller amount would not, the niggardly expenditure certainly would not be in accordance with good engineering.

The sum of the matter is that the perspective or point of view of engineering operations should be from the consideration of the ultimate and complete function of the project and its relation to the complicated social and economic organization rather than from its immediate and limited connection as a technical problem, and that students should be taught to seek the complete and final analysis of a problem rather than the immediate, and perhaps partial or fragmentary, application of its principle.

THE EFFECT OF THE WAR ON ENGINEERING EDUCATION.*

BY C. R. MANN,

Carnegie Foundation for the Advancement of Teaching.

Three years ago most of us thought that a world war could not last long because, however much kings and kaisers might wish to continue, the banker would stop it. But the financiers have not come up to our expectations in this matter, and we have therefore been compelled, unwillingly perhaps, to recognize that money is not the ultimate measure of national strength. National credit is the result and not the cause of intelligent industrial production; the engineer, not the banker, is the real power behind the throne.

This fundamental fact now seems so simple and self-evident that it is rather hard to remember the time when we thought otherwise. But though the rugged outlines of this fact are now sharply silhouetted against the ruddy dawn of the new age, the details of its meaning are but dimly discernible through the haze of speculation over the significance of the struggle. Naturally the engineer is intensely interested in the development of the details of the picture, for on him devolves the duty of interpreting the coming conceptions in terms of materials and organizations of men. And if education makes men, engineering education must be the first to feel the thrill of the dawning day.

Three elements in the picture can now be plainly perceived. These indicate that the engineer is from henceforth vitally involved in the control of credit, in the interpretation of the

* This article was written at the request of the Editor, but appeared in Vol. 80, No. 5, p. 208, *Engineering-News Record.* This is second of a series of articles on the effects of the war on engineering education, being published in this magazine.

daily news, and in the organization of industry and commerce to make goods cheap and men dear.

In performing the first of these new functions, the engineer becomes the partner of the banker to determine which projects are worthy of financial support and which not. As the engineering spirit is more and more infused into this dispensing of credit, public service rather than excess profit becomes the inspiration for enterprise; intelligence in production becomes the best security for loans; ability to deliver the goods becomes the sure basis of financial success; and the control of tools gradually passes from the hands of those who own them legally into the hands of those who can use them effectively.

Newspapers and periodicals already sense the expansion of the engineering spirit in the struggle to make the nation strong. The distribution of wheat, the supply of sugar, the transportation of coal and the price of bread are now subjects which occupy an amount of space in the daily press that only a murder trial could formerly command. The public has never before realized how vital and how interesting factories, freight cars, warehouses, terminals, trucks, and ships really are. Some faint conception of the necessity of organization for the common project of liberating life by winning the war seems to be taking shape; while an impelling desire to serve and to subordinate personal preferences to community interests appears to be dimly developing. These faint feelings of fraternity may grow into driving impulses, if editors continue to extol engineering enterprise rather than private profit in their interpretations of the daily news.

In many communities chambers of commerce or groups of engineers have organized to build up business and boom the town. Through their efforts living conditions have been improved and many a city is being made a better place for homes. But the progress has always been hampered by the vested rights of individuals and of corporations, so that none has yet dared to envisage an entire community as a single working plant for the purpose of organizing it for the most intelligent pro-

duction of human wealth. This can now be done. The war is opening many hitherto blind eyes to see that each gains more than he loses when he merges his strength with the might of all in an organization that is constructed for the purpose of releasing creative energy by giving each the work he is best qualified to do.

The time has come for such an organization in every community and every state, because the federal government is struggling to shape the nation into an organization of this type. Only so may the nation be strong; only so may communities add their utmost to the nation's strength. The responsibility for this work must finally be shouldered by engineers who are both masters of the mechanic arts and moulders of men.

For many years this country has been drifting toward the realization of these requirements. The war has but accelerated the process and precipitated conclusions that were bound to come, otherwise men trained by experience to meet the present crisis could not now be found. Continuity demands that the same conclusions remain valid long after the war is ended. Therefore engineering schools will render service in proportion as they grasp the implications of these conclusions and express them effectively in the daily work of instruction.

The possible conclusions for engineering education are many and complex, but two stand out in bold relief, namely, there must be closer coöperation between school and industry, and there must be more attention to the appraisement of values and costs.

The essential feature of the coöperation with industry is not the skill, the knowledge of workmen, or the feel of the machines which the student acquires from shop experience. Important as these are, they cannot compete with the spirit of investigation which must develop if the coöperation between school and industry is real and vital. There are thousands of unsolved problems in even such rough shop work as

freshmen are permitted to do. The boy should be trained to discover these unsolved problems and to bring them back to school for discussion and solution. By making shop work in industrial plants the source of problems for solution in school, and by relating the class and the laboratory work in some degree to the problems raised, conditions most favorable to the self-development of the student may be realized. As he progresses, the problems become more and more intricate, until in his last year, if he has shown real engineering ability, he may be assigned as helper in industrial research, either at the plant, or in the school laboratories. After such a training in defining and solving problems, closely coördinated with instruction in science and drill in mathematics, he should be able on graduation to take a responsible position without serving several years as an apprentice, as is usual under present conditions.

To the faculty this type of coöperation with industry brings incentives for creative work in production and in education. For coöperation makes the school the source of solutions of industrial problems, not only with respect to the technique of manufacture, but also concerning the correlation of the community's productive processes with the training of its citizens as intelligent workers. Hitherto manufacturing companies have stood aloof and regarded one another with suspicion—and the Federal Trade Commission discovered that 200,000 of them are not paying expenses; but now they are ready to coöperate. Similarly in education, many manufacturers are supporting corporation schools to train their own help, while more than half the children in the entire country quit school at the sixth grade without being trained to earn a living: but they too are now ready to coöperate. If the men who are teaching in engineering schools rise to the responsibility and organize for the systematic study of community production, they could soon create a true university, with its feet firmly planted in industry and its soul consecrated to the

task of utilizing science and literature to liberate the creative energies of men.

While close coöperation between school and industry gives that practical experience which is essential for mastery of the mechanic arts, it is not in itself sufficient to enable the schools to meet adequately the fundamental requirements of engineering in the new epoch. The Germans are technically well trained in the mechanic arts, yet they are but brutally strong. In order to strengthen the nation by infusing the engineering spirit in the control of credit, in the interpretation of the daily news and in the organization of industry for the production of human wealth, the engineer must have sound judgment in the appraisement of values and costs. This requires not only an understanding of finance and the meaning of money, but also a sympathetic appreciation of the things humanity holds to be most worth while. Even a practical project like building a bridge is ultimately controlled by some man's decision that the resulting value is worth the cost; and this decision is more difficult and subtle when it concerns profoundly the production of human wealth and the appraisement of human values and costs. The engineer is too often obliged to be only the employee of the bank, the corporation, or the state commission, because he believed that engineering is wholly a matter of technical skill; when control in this, as in everything else, is really vested in the decision of the question whether the game is worth the candle.

Training in the appraisement of values and costs does not require the addition of formal courses for that purpose, but rather the injection of this point of view into every branch of school work. For example, experiments in chemistry need not always be of the type: Analyze this baking powder. The project: Make baking powder and find out if it is cheaper and better than any you can buy, is vastly more effective as a training exercise. Presented as a personal effort to appraise the human values and costs in life's experiences, literature fascinates engineering students. Economics delights them

when it is a critique of proposed solutions of the social problems defined by their daily coöperation with labor. Such exercises also foster the development of those homely virtues, which always make the working people the bulwark of a nation's strength—the sense of justice, feelings of neighborly kindliness, devotion to right, and respect for God and man.

Thus because the war has revealed a profounder appraisement of human values and costs, and because the war has hastened the transformation of the individualistic man, selfishly seeking his own personal profit, into a community man willing to do his best for the common welfare, the ideal that was set for the engineering schools in the passage of the Merrill Act in 1862 may now be achieved. For many of the first schools founded under that act were called "industrial universities"; but they soon dropped the "industrial" from their titles, fearing lest they lose caste in academic councils. But now, if they gladly grasp the opportunity opening before them, they will claim with pride their abandoned surname and proceed to demonstrate that the engineer, the creator of a new earth, is also the prophet of a profounder philosophy of life.

OUTLINE OF COURSE IN DIRECT-CURRENT MACHINERY.

BY H. C. BARTHOLOMEW,

Associate Professor of Electrical Engineering, Iowa State College.

From the standpoint of methods of teaching, engineering courses may be classified under two heads:

(*a*) Those subjects in which nearly all the material presented is illustrated by the solution of numerical problems.

(*b*) Those subjects in which fifty per cent. or more of the class-room work calls for explanations of fundamental principles and for discussions involving the application of a knowledge of these principles.

Courses of the second class are sometimes difficult to present in such a way that the average student will have a clear idea of the exact nature of the problems he will be called on to solve, since the text may be confined mainly to explanation of fundamental principles and may not state all the problems involving the application of these principles that the instructor would like to present. It is usually unfair to the student to expect that, having learned the fundamental principles, he should be able, in the limited time afforded for examinations, to apply them to the solution of a problem new to him, or even to a problem which has been briefly discussed in class, but is not stated in the textbook.

An outline given to the student in printed or mimeograph form, which states all the questions he will be called on to answer and in general terms all the numerical problems he will be called on to solve, should help him to find out what the course is designed to teach; it should also give the instructor greater latitude in examinations, since the student may reasonably be expected to discuss any topic in the outline.

COURSE IN DIRECT-CURRENT MACHINERY.

The accompanying outline is given in mimeograph form to the electrical engineering students at the Iowa State College taking the course in direct-current machinery. It is arranged for a four-hour course to be taught by the recitation method to students who do not study the design of electrical machinery. So far as possible, questions have been so stated as to require an answer based on the physical rather than on the mathematical viewpoint and stress has been laid on the idea that the function of the course is to teach the student to answer the question "why" and not the question "what." An effort has been made to so word the questions as to require an actual analysis and to eliminate camouflage answers.

While there is room for opinion as to what should constitute a course in Direct-Curent Machinery, the writer believes that this subject can be more efficiently taught with the aid of an outline similar to the one here presented, arranged to suit the conditions under which the course is given.

Outline of Course in Direct-Current Machinery.

The following is an outline of the course in direct-current machinery. Topics in it, together with parts of the text, will be assigned for recitation and for written examinations during the semester. A final examination will cover the entire outline together with the solution of numerical problems. The outline is general in character and is not made out with reference to any particular text, so that it may not follow the order of the text which is used.

Introductory.

1. Elementary explanation of different types (shunt, series and compound) motors and generators.

2. Details of construction of armature, commutator, brush rigging and frame. Only a small amount of time will be given to this topic.

3. Mechanical features and magnetic characteristics of cast iron, cast steel and rolled steel frames, and of cast steel and laminated poles.

4. Paths of useful and of leakage magnetic fluxes and definition of coefficient of magnetic leakage. Reasons why poles cover only about three quarters of the armature surface. (No problems on the magnetic circuit of the dynamo will be given.)

5. Theory of the bipolar and multipolar ring winding (arrangement of winding, position of brushes, connection of brushes, path of current through windings, resistance of armature). This type of winding is obsolete, but is the electrical equivalent of modern windings and is universally used for purposes of explanation on account of its simplicity.

6. The fundamental equation of the dynamo (derivation and application to the solution of numerical problems).

Armature Windings.

7. Theory of simplex and duplex, lap and wave windings, including determination of proper winding and commutator pitches for a given case, determination of reëntrancy of winding, determination of winding to fit case of a given machine generating a given voltage, and use of dummy coils.

8. Solution of problems calling for representation in developed form of armature windings of above types.

9. Paths in parallel, resistances, and voltages generated by above types of windings.

10. Reasons equalizers are necessary in lap windings and are not necessary in wave windings.

11. Reasons why equalizers prevent sparking.

12. Reasons why lap-wound machine with unequal air gaps when putting out its rated current will have greater armature I^2R losses than when putting out its rated current with equal air gaps.

Special Forms of D.-C. Machines.

13. Dynamotor—used for same purpose as motor-generator set.

14. Homopolar generator—has no commutator.

15. Train-lighting generators—designed for variable speed.

16. Automobile generators—designed for variable speed.

Only a small amount of time can be given to these special forms of machines.

Three-Wire Generator.

17. To be covered in course in alternating-current machinery.

Armature Reaction.

18. Theory of the effect of the magnetomotive force of the armature conductors lying under the poles on the distribution of the flux in the air gap.

19. Theory of the effect described in (18) on the total flux per pole and on the generated E.M.F., for a machine operating at no load at a point just above the knee of the magnetization curve. To be discussed for case of light load and for case of heavy load.

20. Theory of the effect described in 18 on the position of the brushes.

21. Theory of the effect of the magnetomotive force of the armature conductors lying within the double angle of brush lead on the main flux and generated E.M.F.

22. Problems involving the computation of armature cross-magnetizing ampere turns, armature demagnetizing ampere turns, and series field turns to compensate for armature demagnetizing ampere turns. The problem of computing the series field turns to compensate for the demagnetizing effect due to the cross-magnetizing action of the armature will not be called for.

23. Discussion of the various schemes of reducing, or of compensating for, the cross-magnetizing effect of the armature.

24. Discussion of the schemes for eliminating, reducing or compensating for, the demagnetizing effect of the armature due to the turns within the double angle of lead (may be eliminated by use of commutating poles; redueed by application of schemes in 23 which reduce brush lead; compensated for, by use of series field winding).

25. Theory of the dependence of the length of the air gap on armature reaction, to include:

(*a*) Discussion of the necessity of providing at the commutating pole tip a main field of greater flux density than that of the field due to the armature cross-magnetizing action.

(*b*) Discussion of the ratio between the field ampere turns per pole used for gap and teeth to the armature cross-magnetizing ampere turns for gap and teeth.

(*c*) Problems calling for determination of the length of the air gap for a given machine to meet the ratio mentioned in (*b*).

The Shunt Generator.

26. Proof that the no-load voltage is at the intersecion of the magnetization curve and the field-resistance line.

27. Conditions under which machine will and will not build up—to include effect of increase in field resistance, high mica, reversal of field connections, reversal of direction of rotation, reversal of direction of residual magnetism, and of operating at speeds below normal.

28. Methods of reversing polarity.

29. Explanation of all reasons for change in terminal voltage with load—to include discussion of effect of armature resistance, armature reaction, change in shunt field excitation, current in short-circuited coil undergoing commutation, and brush contact drop.

30. Explanation of shape of characteristic curve—this must include reasons why the curve drops more and more rapidly as the load is in-

creased, which necessitates an explanation of the variation of voltage drop with load due to each of the factors mentioned in 29.

31. Explanation of effect on characteristic curve of operating a self-excited machine at speeds below normal, but with no-load voltage kept at normal value by change in field rheostat resistance. To be illustrated by a problem.

32. Problem of determination of characteristic curve for self-excited machine from magnetization curve and other data.

33. Problem of determination of volt-speed curve for self-excited machine from magnetization curve and other data, and of determination of critical speed. To be illustrated by a problem.

34. Application—*i. e.*, types of load to which the machine is adapted.

The Series Generator.

35. Practically the same topics as for the shunt generator. The series generator is but little used and not much time will be given to it. No numerical problems to be given.

Special Forms of Series Generators.

36. Thompson-Houston arc-lighting generator. Brush arc-lighting generator.

Will only be mentioned. They are of historical and theoretical interest only.

Compound Generator.

37. Explanation of shape of characteristic curve—this must include reasons why the curve is not a straight line, which necessitates an explanation of reasons why the series field can not be made to compensate exactly at all loads for the drop due to all of the factors mentioned in 29 and of effect of this lack of perfect compensation on the shape of the curve.

38. Adjustment of degree of compounding.

39. Influence on characteristic curve of changing connections from short to long shunt (while it is, in general, not possible to state definitely whether the full-load voltage will be increased or decreased by the change, the factors which tend to change the voltage can be explained).

40. The armature characteristic curve and its use in designing the series field winding.

41. Application—*i. e.*, type of load to which the machine is adapted.

Motors—General.

42. Reasons why motor must develop a counter E.M.F. and the relation between counter E.M.F., line E.M.F. and drop in the armature.

43. Siemens's Law of Efficiency and reasons why the counter E.M.F. should be nearly equal to the line E.M.F.

44. Fundamental formula for speed. Derivation and application to the solution of numerical problems.

45. Fundamental formula for torque and reasons for difference between torque developed within the armature and that developed at the pulley.

46. Reasons why the motor current depends in only an indirect way on the resistance of the armature, but depends primarily on the load. It should be clearly understood that the armature current is *not* equal to the line E.M.F. divided by the armature resistance; one way to illustrate this is to consider the case of a motor, whose speed is controlled by a rheostat in the armature, driving a load demanding constant torque at all speeds, say a plunger pump working against a constant head—what will be the effect on the armature current in this case of varying the resistance in the armature circuit.

47. Influence of armature reactions on brush position and total flux entering the armature (this is in review).

The Shunt Motor.

48. Reasons for shape of speed-current curve. This explanation can be based on the formula derived in 44. It must include the effect of brush contact drop and armature *RI* drop on the numerator of the formula and the effect of shape of magnetization curve, armature reaction, and current in the short-circuited coil undergoing commutation, on the denominator and statement as to the resultant effect of all these factors on the curve.

49. Reasons for shape of torque-current curve. Involves discussion of same factors as in 48.

50. Figures for values of speed regulation in large and small motors.

51. Effect on speed at no load and under load of changes in field, armature and line resistance.

52. Proof that neglecting all factors excepting armature resistance and neglecting drop in armature at no load, the speed regulation is independent of the adjustment of the shunt field rheostat—to be proven by substituting formulas for speed at no load and under load (derived in 44) into formula for speed regulation and simplifying the resulting expression.

53. Effect on current and heating, of operating with line voltage below normal.

Adjustable-speed Shunt Motor with Field Rheostat Control.

54. Approximate change in each of the losses and in heating of commutator, fields and armature with speed. To be illustrated by a numerical problem.

55. Reasons why this type is heavier and more expensive than a constant-speed shunt motor of same horse-power rating, designed to operate at the highest speed of the adjustable-speed motor. This may be explained in various ways. One illustration is the following: consider the case of a four-pole, wave-wound, adjustable-speed motor with a two-to-one speed range.

The motor can develop no more horse power at its highest speed than at its lowest speed (why?). Suppose, however, the motor is re-designed for constant-speed operation at its highest speed by changing its armature winding and using the same field current that was originally used at its lowest speed. What change would be made in the winding and, neglecting the extra heating due to the increased stray power losses, how many times the original rated horse power could the motor develop.

Methods of Speed Control.

56. The methods to be considered are:

(*a*) Field rheostat method.
(*b*) Armature rheostat method.
(*c*) Adjustable air-gap method.
(*d*) Multi-voltage method.
(*e*) Ward-Leonard method.

57. Explain reasons for following advantages of (*a*) over (*b*):

(1) Higher efficiency.
(2) Better speed regulation.
(3) No reduction in horse-power capacity at low speeds.

Note.—In an examination, this might be stated: state all advantages of (*a*) over (*b*) and explain reasons for each of the advantages. This note applies to all similar questions in this outline.

58. Explain reasons for following advantages of (*b*) over (*a*) and (*c*):

(1) Greater speed range.
(2) Less total cost for motor and rheostat.

59. Explain reasons for greater speed range of (*c*) than (*a*)—for non-commutating-pole motors.

60. Explain arrangement of (*d*) and its advantage over (*a*).

61. Explain arrangement of (*e*) and its advantage over (*a*).

62. Approximate motor current and efficiency with fan load (torque varies as square of speed) driven by motor with armature rheostat con-

trol, at half-rated speed. Current to be expressed in terms of current at rated speed. Also approximate rheostat loss at half speed in terms of motor input at full speed. This last answer will show one of the reasons why this method of control is sometimes used for driving fans.

63. Same as 62 except for a constant torque load, say a plunger pump working at variable speed against a constant head. Note difference in rheostat loss in the two cases.

Series Motors.

64. Reasons for shape of speed-current curve. See 48 for factors to be considered.

65. Reasons for shape of torque-current curve. See 49 for factors to be considered.

Series-Parallel Control.

66. Connections of motors and rheostat on the various resistance, running and transition notches.

67. Advantages of series-parallel control.

68. Changes in torque of motors during transition from series to parallel.

Cumulative-Compound Motors.

69. Same questions as for series motors.

Differential-Compound Motors.

70. Same questions as for series motors.

71. Effect of operating a motor with a rising speed characteristic curve on a load whose torque increases with speed.

Application of Motors.

The student should be able to apply the correct type of motor to a service with the requirements of which he is familiar and should be able to give the reasons for using the type of motor selected. A few typical examples will be studied and the text will be supplemented by references in the handbooks to some of these examples.

72. Reasons for superiority of the series motor over other types for operating crane hoists, electric shovels and for railway service.

73. Reasons for superiority of compound motors over shunt or series motors for loads which require fly-wheels (for example, a punch) and the effect on the load curve of using the compound motor and fly-wheel, instead of a shunt motor.

74. Reasons why a compound motor when operated with a weak shunt field has very poor speed regulation, so that compound motors are not adapted, for constant-speed applications, to a wide range of speed con-

trol by means of a field rheostat. To be illustrated by a numerical problem.

75. Reasons for advantage, for heavy elevator service, of a compound motor with arrangement to short-circuit the series field when up to speed, over a plain shunt or a plain compound motor of the same horse-power rating. Starting torque and speed regulation are the factors to be considered. Make a comparison of the three motors when designed for the same speeds at no load, and also a comparison assuming they are all designed for the same speed when raising the elevator while carrying its rated load.

76. Reasons for advantage, for high-speed elevator service, of a 2:1 adjustable speed shunt motor with field rheostat control, over a compound motor with arrangement to short-circuit the series field when up to speed. The factors to be considered are those mentioned in 75 and, in addition, simplicity of control and dynamic braking. The last is of great importance in high-speed work where a mechanical brake is not so satisfactory as dynamic braking. Make a comparison of the two motors when designed for the same horse-power rating, the same torque when starting the elevator with normal starting current and the same speed when raising the elevator while carrying its rated load.

77. Reasons for advantage of a constant-speed shunt motor with armature rheostat control over an adjustable-speed shunt motor with field rheostat control for driving a fan requiring adjustable speed, but running most of the time at its highest speed. The speed range of the fan is to come within the speed range of the adjustable-speed shunt motor (*i. e.*, the advantage of the armature rheostat control scheme in this case is not its greater speed range). See (55), (62) and (63) for factors to be considered.

78. Reasons for advantage of adjustable-speed shunt motor with field rheostat control over a constant-speed shunt motor with armature rheostat control for driving a fan requiring adjustable speed, but running most of the time at its lower speeds. See 77 for factors to be considered.

79. Reasons for advantage of compound motor over shunt motor for operating planers with mechanical reversing arrangement.

80. Reasons for advantage of shunt motor over compound motor for operating lathes and drill presses. Factors to be considered are speed regulation and the factor discussed in 74.

81. Reasons for advantage of Ward-Leonard system over other systems of control for operating large motors used for reversing service, as in reversing service in steel mills. Factors to be considered are (*a*) simplicity and low cost of controller, (*b*) efficiency (*i. e.*, combined efficiency of motor and control rheostats) and (*c*) use of fly-wheel.

Starting Boxes.

82. Connections of three and four terminal types of boxes.

83. Connections and operation of overload and of no-voltage release coils.

84. Connections of starting and regulating box.

85. Connections of:

(*a*) Arcing tip to take initial and final arc.

(*b*) Laminated copper brush to short-circuit the sliding contact on last notch.

(*c*) Arrangement to cut starting resistance out of field circuit on last notch.

(*d*) Arrangement on starting and regulating box to short-circuit field rheostat while starting.

86. Essential difference between three and four terminal types.

87. Reason that four terminal type is usually used for adjustable-speed motors using field rheostat control.

Note.—Only a small amount of time will be given to this topic and it may be practically omitted. This subject can well be learned in the laboratory.

Automatic Starters.

88. This subject is not to be covered.

Commutation.

89. Statement of condition (complete reversal of current during time of commutation) for perfect commutation.

90. (*a*) Complete explanation of reasons why sparkless commutation will result if condition in 89 is met. Explanation is to include a representation of a portion of a ring-wound armature at one of the brushes, showing conditions when the coil undergoing commutation is just at the end of the period of commutation. On the sketch are to be shown direction of rotation and direction and relative magnitude of all currents:

(1) In coil undergoing commutation.

(2) In coils adjacent to coil undergoing commutation.

(3) In commutator risers of coils mentioned in (1) and (2).

(4) In lead attached to brush.

(5) Arcing between edge of brush and commutator segment just leaving brush.

(*b*) Complete explanation with diagram similar to that in (*a*) of reasons why sparking will result if condition in (89) is not met.

91. Explanation of effect of inductance of coil undergoing commutation in tending to prevent condition stated in 89.

92. (*a*) Statement of condition to be met for neutralizing the effect of the E.M.F. of self-induction of coil undergoing commutation (equality of E.M.F. of self-induction and E.M.F. of rotation of coil undergoing commutation).

(*b*) Mathematical expression for E.M.F. of self-induction of coil undergoing commutation, under conditions of perfect commutation, in terms of coefficient of self-induction, current per coil and time of commutation.

93. Explanation of direction of brush shift from magnetic (as distinguished from geometric) neutral to obtain the E.M.F. of rotation mentioned in 92. To be explained for both motor and generator.

94. Explanation of way in which brush contact resistance will accomplish reversal of current mentioned in 89 if condition mentioned in 92 (*a*) is effected. To be explained by means of diagrams similar to that mentioned in 90, showing conditions at beginning of commutation and when commutation is one fourth, one half, three fourths, and fully, complete.

95. Reasons why a shunt generator running at no load will spark if the brushes are shifted either way from the geometric neutral.

96. Explanation of the following, for each case to be based on:

(*a*) Change in E.M.F. of self-induction, determined from formula called for in 92.

(*b*) Change in strength of commutating field (can be stated only approximately in some cases).

(*c*) Change in speed at which coil undergoing commutation cuts the commutating field.

(*d*) Change in E.M.F. of rotation of coil undergoing commutation (determined from (*b*) and (*c*)).

(*e*) Change in relation between E.M.F. of self-induction and E.M.F. of rotation of coil undergoing commutation (*i. e.*, the final explanation is to be based on the criterion for perfect commutation stated in 92).

Case I. Commutation at full load of a shunt generator which has perfect commutation at half load.

Case II. Commutation at 1,200 R.P.M. of a 600–1,200 R.P.M. adjustable-speed shunt motor using field rheostat control, which commutates perfectly at 600 R.P.M.

Case III. Superior commutating quality of series motors under varying loads, over shunt motors under varying loads.

COMMUTATING-POLE MACHINERY.

97. Explain polarity of commutating poles for case of motor and for case of generator.

98. Armature reaction in commutating-pole machinery.

(*a*) Reasons why the effect in 21 is eliminated.

(*b*) Reasons why the effect in 18, for the air gap under the main poles, is practically not affected by the introduction of commutating poles.

99. Commutating-pole magnetic circuit and magnetomotive force of commutating-pole winding necessary for this circuit.

100. Variation in flux in commutating-pole air gap with load.

101. Reasons for use of neutralizing winding.

102. Effect on voltage of generator and on speed of motor of operating with brushes shifted ahead of, and back of, the commutating-pole neutral.

103. Reasons for use of compensating windings in the pole face, in commutating-pole machines.

104. Reasons for the very poor speed regulation of a commutating-pole motor run with the commutating-pole winding cut out, but with the commutating poles left in position, and brushes left on the commutating-pole neutral.

105. Explanation of the following, for each case to be based on the same factors as those mentioned in 96:

Case I. Reasons why commutation of a shunt generator will be practically perfect at all loads, if perfect at any one load.

Case II. Reasons why commutation of an adjustable-speed shunt motor, using field rheostat control, will be practically perfect at all speeds, if perfect at any one speed.

Flash Over.

106. Discussion of influence in starting flash over on sudden overload of:

(*a*) Voltage induced by shifting of cross flux.

(*b*) Vapor set up by arcing at brushes.

107. Reasons for difference in ability to withstand flash over of same machine when operated:

(*a*) As a motor.

(*b*) As a generator.

Parallel Operation.

108. Connections for commutating-pole and for non-commutating-pole generators.

109. Reasons for instability of overcompound generators in parallel without equalizers.

110. Reasons for stability of overcompound generators in parallel without equalizers, when in different stations with resistance in the line, as in railway work.

111. Reasons for stability of undercompound generators in parallel without equalizers.

112. Statement of conditions to be met for perfect division of load between machines of different capacities and explanation of reasons.

113. Explanation of reasons why it may be impossible to effect the proper load division by adjustment of series shunts.

Efficiency and Losses.

114. Formula for hysteresis loss and for eddy current loss of a given dynamo, in terms of speed and flux density.

115. Explanation of variation of hysteresis, eddy current, bearing friction, brush friction, windage, field copper, armature copper and brush contact losses, with load, in:

(*a*) Shunt motor.
(*b*) Series motor.
(*c*) Flat compound generator.
(*d*) Overcompound generator.

116. Explanation of variation of losses mentioned in 115 with speed, in adjustable-speed shunt motor using field rheostat control. To be illustrated by a numerical problem.

117. Explanation of eddy current losses in pole face.

118. Definition of stray power loss.

119. Definition and Explanation of stray load losses. See A. I. E. E. Standardization rules, Sections 219 and 220.

120. Principle which fixes load at which maximum efficiency occurs. Derivation and application to the solution of numerical problems.

121. Approximate efficiency of machines of various sizes.

122. Approximate load at which maximum efficiency occurs in commercial machines.

123. Experimental method of determining stray power loss which a dynamo will have under various loads. This topic will be covered by an experiment in the laboratory course and will not be studied in the classroom.

Dynamic Braking of Series Motor used for Hoisting Service.

124. To be illustrated by a numerical problem.

UTILIZING ENGINEERING STUDENTS—A NEED AND A PLAN.*

Hardly had the engineering schools and the profession adjusted themselves mentally to the rulings promulgated by General Black, whereby engineering students might complete their training, before the Signal Corps proposed a different plan which it hopes will produce 500 graduates of the class of 1918 who will be adept in the theory and practice of radio-engineering. Another method this, differing in particulars, but with results much the same—a second enlisted reserve to be composed of physically fit students above eighteen years of age who will devote the full time of the second term of their senior year to the study of those topics which will fit them to a special purpose, that of military communication.

This proposal has not yet been passed upon by the Secretary of War, but before the echoes of its announcement have died away, rumor has it that the Ordnance Department is to come forward with a third plan, couched in very similar terms and intended to reserve a few hundred mechanical and chemical engineers for specialized training. Nor is even this the end. At the recent meeting of the American Physical Society resolutions were passed petitioning that additional regulations be made permitting certain students in pure science in the universities to complete their studies to the end that they may more thoroughly function in such technical research as will prove of most benefit to war industries or to the military arm of the country.

This situation cries for a centralization of intelligence and authority. However unfortunate it may be, the moment finds Washington with no committee or board properly constituted to undertake the work of examining either the needs of the various and partially conflicting branches of the service, or

* Reprinted from *Engineering News-Record*, Vol. 80, No. 2.

the most efficient and practicable methods of serving them. True, the Federal Board for Vocational Training has offered its appropriation and organization to this end and has, in a measure, rendered a certain aid to the Signal Corps. But the board recognizes and admits that in matters of higher education it can serve only as an administrative organ, and attempts to handle the question by merely bringing the representatives of the engineering schools to Washington so that they may discuss with army officers, in a huge debating society, the details of an adequate curriculum. Certainly it does not seem reasonable that a board, limited by law to the study and furtherance of secondary education and effectively organized solely to that end, could also be the proper agency to undertake the mobilization of the universities and colleges of engineering—even though war does justify many expedients.

Soon Secretary Baker must come to a decision which will result in order. The possibility of third-rate medical schools flourishing as refuges for draft dodgers is atrocious. Nor is there anything of particular appeal to loyal engineers in the thought that the technical schools, cross-raked by the needs of different services, may be given the opportunity to degenerate into nests for similar intriguers. A complete coördination of the existing conflicts of interest must be effected immediately.

The *Engineering News-Record* believes that a new agency should be created for this purpose. The need is so paramount that the superficial complications of one more board or committee is of no consequence if some semblance to the rational may result. What is needed is a small body of authorities, with investigational and advisory power, through which the resources of all institutions maintained for higher scientific education may be adjusted to military needs. This body of men would find it a simple matter, and one consuming but little time, to reduce the fast-growing complexity to an ordered plan.

Lest there be the usual accusation that it is easier to pro-

pose a general scheme than to reduce it to practice, the *Engineering News-Record* advances the following program:

Let the Secretary of War appoint a board composed of an officer of the general staff; one man thoroughly representative of the medical, dental and veterinary schools; a man who can speak with knowledge of the situation existing in colleges teaching pure science; an authority in higher industrial education; and someone who is competent to speak for the engineering schools. Such a board could make a study of the necessities of the army for young men trained in science or its application, and from it would issue the advice as to how the demand could be filled with the greatest despatch and with the least interference with the progress of other war preparations. They could devise the needed courses of instruction, could rule on the fitness of this or that school to supply the needed training, and, counting on the undoubted loyalty of these institutions, could suggest means through which existing educational facilities might best be utilized to the advantage of all concerned.

It should not be difficult to find men thoroughly equipped for this work. But immediate action is called for, and if reason is to rule, some method such as is suggested above will soon be adopted.

EDITORIAL.

1918 Meeting.—It is almost the instinctive feeling of everyone that the number of meetings of societies should be reduced to a minimum during the war, but this is at once modified by the value which such a meeting may be to the war and the re-construction period which is to follow. The 1917 meeting held in Washington provided a clearing house for discussion of the questions arising in connection with the war and engineering schools at the very beginning of the war. Many of us at this meeting received information which led us to modify greatly our point of view in regard to the relation of engineering schools to the government. Since that time this Society has done a number of things to promote the closer relation of enginering schools to the national government.

It seems to the Editor that the 1918 meeting should be held and that it should be devoted largely to the discussion of the new problems which have arisen in engineering education as the result of our participation in the war. Many of these questions must be solved immediately; many are developing and will be solved only in the years following peace. It may be possible that the attendance at such a meeting will be small because of the very large number of engineering teachers engaded in active war work. However, the presentation of the various questions, the free discussion and immediate publication will assist everyone in the solution of his own particular problem as well as the general problems which confront every school.

LETTERS TO THE EDITOR.

Dear Sir: An article of mine entitled "Some Factors in Student Scholarship" was printed in the November issue of the BULLETIN, p. 98, and a mention was made in it of psychology of study in some of its practical aspects. A number of requests have come to me to explain the last paragraph on

p. 99 more in detail, or to write an article on psychology of study.

May I call the attention of your readers to a small book by Guy Montrose Whipple, professor of education at the University of Illinois, entitled "How to Study Effectively" (Public-School Publishing Co., Bloomington, Ill., 1916). The booklet comprises only 42 pages and consists of 38 definite rules written for high-school students. The rules should also apply well to college students. A bibliography is appended for further reading on the theory of study.

Some day someone may write a similar book for teachers and investigators, showing them on an exact physiological and psychological basis how to plan their life most efficiently for teaching, study, research, social service, recreation and rest. In the meanwhile one has to apply to grown-ups the results of study on children and youths, supplementing it by general works on psychology of attention, memory, perception, etc.

Very truly yours,

V. KARAPETOFF.

BOOK REVIEWS.

The Composition of Technical Papers. By H. A. WATT. McGraw-Hill Book Co. 1917. $5\frac{1}{4} \times 7\frac{3}{4}$. 431 pages.

This is one of the most satisfactory books which have appeared for use in a course of technical English. The author has assumed that the student is but slightly informed both as to technical theory and as to the principles of composition. Therefore, adopting the conventional arrangement of chapters, he has handled the whole composition, the paragraph, and the sentence concisely and with a judicious selection of none too technical examples. In the chapter on the sentence the simplicity of his treatment is perhaps too elementary, since he has devoted several pages to the grammar-school method of diagramming sentences. In the choice of examples to illus-

trate paragraph development, he has skilfully shown wherein the methods for constructing the literary paragraph should also apply to the technical. In the articles inserted to make clear the structure of the whole composition, the author has wisely included some that are specifically faulty for correction, as well as a few that shall serve as models. There is a chapter on business letters exceptionally good because the principles deduced are based on the actual practice of careful firms. For use by upperclassmen who have already had training in composition, the text is possibly too elementary; for use by freshmen, the instructor will probably desire to supplement it with a reference book particularly devoted to grammar. If a student wishes independently of a classroom to correct his faulty composition, we can recall no text more complete or clear in serving his purpose.

E. B. B.

The Elements of Non-Euclidean Geometry and Trigonometry. By H. S. CARSLAW. Longmans, Green & Co. 1916. 5 × 7½. 180 pp. $1.50 net.

Non-Euclidean Geometry is written primarily for the use of teachers of elementary geometry. The early chapters of the book are historical in form and treat of Euclid's Parallel Postulate and the work of various men in attempting to prove this theory. In conjunction with this is given a description of the work of Bolyai, Lobatschewsky, and Riemann, the founders of non-Euclidean geometry.

Chapters III–V treat further of the geometry of Bolyai and Lobatschewsky, dealing particularly with the various theorems of parallel constructions.

Chapter V treats of the measurement of length and area, with the aid of the infinitesimal calculus.

Chapters VI–VII are a development of the elliptic geometry while Chapter VIII deals with Poincaré's representation of the non-Euclidean geometries by the geometry of circles orthogonal and diametral to a fixed circle, showing the impossibility of proving the parallel postulate.

The book is terse and the subject-matter at the same time well handled. A large number of theorems are covered for so short a volume.

E. F. L.

COLLEGE NOTES.

Lafayette College.—A revision of the curricula of the courses in chemical, civil, electrical and mechanical engineering has just been effected, the details of which will appear in the forthcoming college catalogue.

In the new curricula special emphasis is laid on the fundamentals. In order to provide ample time for them it was found necessary to reduce the specialized engineering subjects as requirements, though still continuing to offer them and in even fuller measure as electives. Modern languages have been removed from the freshman year as a requirement but are offered later as electives. The entering students are introduced at once to practical engineering problems in mathematics, the work being done in three-hour periods in the presence of the instructor. Surveying is begun at the middle of the freshman year. General electives are offered in the sophomore year, and general and technical electives of wide range in the senior year.

The freshman year will be common to all courses. Differentiation is provided in the sophomore year in the "course subject," coming three periods per week, which will be Qualitative and Quantitative Analysis for Chemical Engineers; Surveying and Railroads for Civil Engineers; Electricity for Electrical Engineers; and Mechanical Technology for Mechanical Engineers. The sophomore elective of three periods per week for both terms may be made in English literature, history or modern languages. It will not be difficult therefore for a student to change his course even as late as the end of the sophomore year.

Especial attention has been given to the planning and coordination of the subject of mechanics, given throughout the junior year. A part of the allotted time will be devoted to

the solution of practical problems in three-hour periods under the supervision of the instructor in charge. Economics is given both terms, three periods per week.

Electives will be provided in the senior year in different specialized branches of the course in question; also in economics, government, psychology, history, etc.; and in other engineering subjects not coming strictly within the scope of the particular course. These senior electives amount to nine periods per week for the first term and six for the second.

The degrees offered are B.S. in Ch.E., in C.E., in E.E., and in M.E.

Electricity has leveled out the Continental Divide

Notable G-E Steam Road Electrifications

1896—Baltimore & Ohio Tunnel
1906—New York Central Terminal
1906—West Jersey & Seashore
1906—Great Northern
1910—Detroit River Tunnel
1911—Southern Pacific
1913—Butte, Anaconda & Pacific
1916—Chicago, Milwaukee & St. Paul
1917—Victorian Railways, Australia

HIGH among the bald peaks of the Montana Rockies, 6,000 feet above the sea, the high-speed, smokeless passenger trains and record-tonnage freight trains of the Chicago, Milwaukee & St. Paul wind their way up and over the Continental Divide, under electric power. These trains cross four hundred miles of the same mountain ranges that years before meant weeks of perilous travel to horseman or prairie schooner; over the same tracks where a few months before giant steam locomotives had faltered on the up-grades and heated their brakes to redness while descending.

Half a hundred G-E electric locomotives are daily climbing the Continental Divide, making faster time than their steam predecessors, hauling heavier loads, and by means of regenerative electric braking on the down-grades are returning power to the wires, effecting vast economies. Conservation of approximately half a million tons of coal a year is one of the epoch-making results.

Immune to the biting cold that freezes motion from steam locomotives, freed from carrying tons of fuel and water, the trans-continental electric locomotive is now a 3,000 horse power reality—another General Electric Company achievement.

7518

GENERAL ELECTRIC COMPANY

This immensely valuable catalogue sent free on request

A DESCRIPTIVE LIST OF

TECHNICAL BOOKS

Prepared by a Committee of the

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

This is a reprint of the list issued in 1905, with a supplement consisting of newer books recommended by EDWARD F. STEVENS, Librarian of the PRATT INSTITUTE FREE LIBRARY.

The above list includes but a small portion of our extensive stock of technical and scientific books. We invite correspondence with this department of our store, and also recommend our MONTHLY BULLETIN OF NEW BOOKS, giving descriptions of all new books both general and technical, which will be sent free to any address.

A. C. McCLURG & CO.

218-224 South Wabash Avenue CHICAGO

THE NEW ERA PRINTING COMPANY

LANCASTER, PA.

is prepared to execute in first-class and satisfactory manner all kinds of Printing, Electrotyping and Binding. Particular attention given to the work of Schools, Colleges, Universities and Public Institutions

Books, Periodicals

Technical and Scientific Publications

Monographs, Theses, Catalogues

Announcements, Reports, etc.

All Kinds of Commercial Work

Publishers will find our product ranking with the best in workmanship and material, at satisfactory prices. Correspondence solicited. Estimates furnished.

THE NEW ERA PRINTING COMPANY

The Bulletin of the Society for the Promotion of Engineering Education

PUBLICATION COMMITTEE

Milo S. Ketchum, G. R. Chatburn, F. L. Bishop

The Bulletin is the official organ of the Society. It is published monthly from September to June. It contains not only the text of papers presented before the Society, but also college notes, short contributions from members, and matters of general interest to all persons connected directly or indirectly with technical education.

The Society comprises about fifteen hundred teachers, engineers and other persons interested in technical education and a considerable number of educational institutions.

Subscription Price

The membership fee includes one subscription to the Bulletin. To non-members and libraries, the price of the Bulletin is $2.00 per year. Libraries may subscribe for the Bulletin and Proceedings for $4.00 per year.

Communications regarding subscriptions, advertising and editorial matter should be addressed to **The Bulletin of the Society for the Promotion of Engineering Education, 41 North Queen Street, Lancaster, Pa., or to the Editor, Dean F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.** Remittances should be drawn to the order of **Mr. W. O. WILEY, Treasurer, 432 Fourth Avenue, New York.**

Study the Instrument Question

Only when you have studied it by direct comparison will you realize fully what a high degree of efficiency you can effect by selecting

Weston

Indicating Instruments

As soon as you inspect them—even before you subject them to the test of comparison—the reasons for their acknowledged superiority will be apparent to you. These reasons are revealed in every structural detail.

Weston D.C. Miniature Precision Instruments

are masterpieces of electrical and mechanical workmanship. They are accurate, dead-beat, extremely sensitive, effectively shielded and legible.

The group includes Voltmeters, Ammeters, and Volt-Ammeters, both portable and switchboard, of various models and ranges, which offer a selection from over 300 different combinations. Battery Testers are also included.

WESTON ELECTRICAL INSTRUMENT COMPANY

3 Weston Avenue, Newark, N. J.

New York	Boston	Chicago	St. Louis	San Francisco	Winnipeg	London
Philadelphia	Richmond	Cincinnati	Detroit	Montreal	Vancouver	Paris
Pittsburgh	Buffalo	Cleveland	Denver	Toronto	Petrograd	Florence

TIMBIE & HIGBIE'S BOOKS

Alternating Current Electricity

And Its Applications to Industry

By W. H. TIMBIE

Head of the Department of Applied Science,
Wentworth Institute, Boston, Mass.

and H. H. HIGBIE

Professor of Electrical Engineering,
University of Michigan.

FIRST COURSE, Total Issue, 9,000. x+534 pages. 5½ by 7½. 389 figures. Cloth, $2.00 net.

Planned to meet the need for an elementary text on alternating-current electricity, simple enough to be readily understood by beginners, and, at the same time, complete enough to be a proper foundation for engineering practice or for later advanced study.

The book contains, in Chapter I, a brief, general discussion of the ways in which alternating-current and alternating-current machinery are commonly used, and the place that they occupy in the larger field of power generation and distribution. Theoretical demonstrations and discussions are preceded in every instance by practical explanations.

SECOND COURSE, Total Issue, 4,000. ix+729 pages. 5½ by 7½. 297 figures. Cloth, $3.00 net.

This second course, which supplements the authors' first course, but which is also complete in itself, explains in greater detail matters relating to the construction and the characteristics of operation of the various common types of alternating-current machines, and appliances. Each of these machines and appliances is studied in its relation to all of the principles that have been brought out in the earlier course.

(In Preparation, by the Same Authors)

Essentials of Alternating Current. (Ready, fall, 1918)

JOHN WILEY & SONS, Inc.

432 Fourth Avenue, New York City

London, CHAPMAN & HALL, Ltd.

Montreal, Can.: BENOUF PUBLISHING CO. E E 2-18 **Manila, P. I.:** PHILIPPINE EDUCATION CO.